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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAMME OF THE

CHICAGO MEETING

AT

THE UNIVERSITY OF CHICAGO

CHICAGO, ILLINOIS

November 27–28, 1942

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The American Physical Society

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of the

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BULLETIN

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AMERICAN PHYSICAL SOCIETY

CHICAGO MEETING, NOVEMBER 27–28, 1942

THE **"Thanksgiving meeting" of 1942,** being the 251st of the American Physical Society, will be held as usual in Chicago on Friday and Saturday, November 27 and 28. As usual also, our host will be the University of Chicago, and the Physics Club of Chicago will join us. The war however has preëmpted our usual meeting-rooms, and the sessions will be held in buildings of the campus hitherto unfamiliar to most of us; but the registration desk will be set up in the familiar surroundings of Eckhart Hall (Room 119) and directions will there be given for reaching the scenes of the meetings. The first session begins at 2 P.M. on Friday.

Hotel. Our usual hotel headquarters, the Windermere East at 1642 East 56th Street, offers rooms at $3.50 single, $6.00 double. Reservations should be made as early as possible, by letter to the hotel with mention of the Society. Members are reminded that it is the practice of hotels not to hold reservations into the evening hours, unless specifically so requested (with an indication of the presumptive hour of arrival of the guest). Very early reservation of Pullman space is strongly recommended.

Invited papers. Three lectures will be given by invitation, the speakers and their topics being these:

Applications of nuclear physics to the biological sciences. J. G. HAMILTON, *University of California at Berkeley,* or I. PERLMAN, *University of Chicago.* Friday at 4:30 P.M. Mr. Perlman has kindly consented to speak if Mr. Hamilton is unable to come, and will avail himself in part of material supplied by Mr. Hamilton.

Problems in the theory of atmospheric cosmic-ray showers. P. AUGER, *University of Chicago.* Saturday at 9:30 A.M.

The theory of random processes. G. E. UHLENBECK, University of Michigan. Saturday at 2:00 P.M.

Contributed ten-minute papers will be presented in three sessions beginning Friday at 2:00 P.M., Saturday at 10:30 A.M. and at 2:45 P.M.

The **dinner** of the Society and the Physics Club will be held on Friday evening at seven in the Quadrangle Club (southeast corner of 57th Street and University Avenue) at a price of $1.50. Among the after-dinner speakers will be P. Auger, who will describe the *Centre National de la Recherche* in France with which he was closely associated. Tickets must be bought at the registration-desk not later than two P.M. Members expecting to arrive later than this hour are requested to notify Professor A. J. Dempster (at the University of Chicago) in advance.

The **Council** will meet on Friday morning at 10:45, at a place not yet chosen which will be indicated to Council members by card.

Prospects for the Annual Meeting. The Annual Meeting of the American Physical Society will be held in New York City at Columbia University on Monday, Tuesday and Wednesday, the 28th, 29th and 30th of December; a meeting of the American Association of Physics Teachers on the 29th, 30th and 31st. Contributed papers will probably be set for Monday morning and afternoon and for Tuesday morning, the annual business session for Tuesday morning. On Tuesday afternoon it is planned to join with the

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American Society for X-Ray and Electron Diffraction in their programme, which will comprise an invited paper or papers. At five in that afternoon we are invited to join the Mathematical Society at the Gibbs Lecture, "The ergodic theorem in statistical mechanics," by J. H. von Neumann. The dinner will probably be held on Tuesday evening, preceding the Sigma Xi lecture by J. T. Tate. On Wednesday it is planned to join two sections of the American Association for the Advancement of Science in a symposium on Galileo and Newton. Should the meeting of the A. A. A. S. be curtailed, we propose nonetheless to proceed with our own plans if possible at all.

Subsequent meetings are intended as follows:

253. December 29, 1942. University of California at Los Angeles.
254. Latter part of February, 1943. Time and place to be designated.
255. Late April or early May, 1943. Time and place to be designated.

General Rules Relating to Papers

By vote of the Society on December 27, 1940, no paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for that meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of these abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

Karl K. Darrow, *Secretary*,
American Physical Society,
Columbia University, New York, New York

PROGRAMME

Session A

FRIDAY AFTERNOON AT 2:00

Room 117, Pathology Building

Contributed Papers

1. Disintegration of the Long-Life Radioactive Isotope of Tantalum. R. V. ZUMSTEIN, J. D. KURBATOV, AND M. L. POOL, *Ohio State University.*—Two radioactive isotopes of tantalum have been reported, Ta^{180}—8.2 hr. obtained by activation of tantalum with fast neutrons and Ta^{182}—97 days by activation with slow and fast neutrons. The second period has now been produced by a prolonged deuteron bombardment of tantalum. It emits intense gamma-radiation with energy of 1.67 Mev. Beta-rays have been resolved into the following groups: 0.98±.1 Mev; 0.32±.04 Mev and approximately 50 kev. The half-life obtained independently from gamma- and beta-radiation measurements is 117±3 days. In addition to the disintegration of Ta^{182} to W^{182}, the third group may be interpreted as evidence for the disintegration of Ta^{182} to Hf^{182} by means of *K*-electron capture. A stable isotope of Hf^{182} is therefore indicated.

2. Transmutation of Barium. KATHERINE E. WEIMER, M. L. POOL, AND J. D. KURBATOV, *Ohio State University.*—New evidence has been obtained for the existence of a radioactive barium isotope with half-life 29±0.5 hours after barium was bombarded with 10-Mev deuterons and fast neutrons. The energy of the beta-rays emitted is estimated to be 260 kev. Low intensity gamma-rays with energy of approximately 340 kev are found to be present. X-rays corresponding to the *K* series of barium have been observed. Deuteron bombardment of barium has also yielded an isotope with 14.2 day half-life, which is identified with a previously reported barium isotope with same half-life obtained by bombardment of cesium with deuterons. This confirms the assignment as Ba^{133}. The ratios of radiation intensities of barium isotopes produced by deuteron bombardment have been computed. Bombardment of barium with protons revealed a lanthanum isotope with 17.5-hr. period. Activation of cerium with fast neutrons produced Ba^{139} with half-life of 85 minutes, but radiation intensity was not sufficient to identify a longer period. Bombardment of cesium with α, d, and p did not reveal 29-hr. barium. Nuclear reactions observed and type of radiations emitted by 29-hr. barium suggest isomeric position of it with one of a stable isotope of barium, probably Ba^{135}.

3. Thresholds for the Nuclear Photoeffect. G. C. BALDWIN AND H. W. KOCH, *University of Illinois.*—By integrating the voltage on the main coils of the 20-Mev betatron with an RC circuit, the orbit expander can be actuated when a predetermined amount of flux has been linked with the electrons' orbit. This permits continuous energy control and defines the peak x-ray energy more precisely than the phase-shifting method previously described.[1] This technique has been applied to measurement of threshold energies for the (γ, n) reaction. Activities are measured with thin-walled G-M counters as a function of maximum x-ray energy, the resulting curves permitting the threshold to be estimated closely. Preliminary measurements indicate the following thresholds in Mev: Cu (10 m), 10.2–10.5; Mo (17 m), 12.8–13.2; Fe (9 m), 13.8–14.0; O (2 m), 16.0–16.5; C (21 m), 19.0–19.4. The limits given are set by accuracy of detection. Absolute calibration may lead to systematic revision of these figures, but they are considered reliable to within 400 kev. The threshold for carbon agrees, within the limits of error, with that expected from known data. Other reactions are being investigated.

[1] D. W. Kerst, Rev. Sci. Inst. **13**, 387 (1942).

4. The Nuclear Excitation of Indium by X-Rays and Electrons. BERNARD WALDMAN AND MARCELLUS L. WIEDENBECK, *University of Notre Dame.*—Using x-rays produced by a pressure electrostatic generator, nuclear excitation experiments[1] on indium were extended to 2.85 Mev. The threshold for the process is 1.12±.03 Mev and activation levels are found at 1.55 Mev, 2.13 Mev, and 2.64 Mev. The direct excitation of indium by electrons[2] showed the same threshold and activation levels as the x-ray excitation. Since the electron beam is homogeneous the electron excitation curve was a series of peaks indicating resonance absorption of the electrons by the indium nucleus.

[1] Waldman, Collins, Stubblefield, and Goldhaber, Phys. Rev. **55**, 1129 (1939); Collins and Waldman, Phys. Rev. **59**, 109 (1941).
[2] Collins and Waldman, Phys. Rev. **57**, 1088 (1940).

5. A High Energy Gamma-Ray from Radio-Yttrium (100 Days). G. R. GAMERTSFELDER,* *Urbana, Illinois.*—It has been known for some time that Rd Y (100 days) emits γ-rays of about 1.9 Mev[1,2,3] and 0.9 Mev[2,3] in cascade. The transition of about 2.8 Mev, corresponding to the sum of these energies, appears to be "forbidden" and has not been observed so far. It seemed worth while to search for this transition with a more sensitive method than those previously employed. If this 2.8-Mev γ-ray were emitted, one should be able to observe with it the photo-disintegration of deuterium (threshold 2.17 Mev). A Rd Y source of a few millicuries intensity which had been produced in the 60" cyclotron in Berkeley by bombarding strontium with deuterons was available for this investigation. A

search for photo-neutrons from Rd Y+D_2O was made and was successful. The intensity of the 2.8-Mev γ-ray was compared with that of the 1.9-Mev γ-ray by a series of experiments and found to be about 1 percent.

* Now at the Radiation Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts.
[1] G. Scharff-Goldhaber, Phys. Rev. **59**, 937A (1941).
[2] J. R. Richardson, Phys. Rev. **60**, 188 (1941).
[3] J. R. Downing, M. Deutsch, and A. Roberts, Phys. Rev. **60**, 470 (1941).

6. A Method for Measuring Total Cross Sections for Low Energy Neutrons. C. O. MUEHLHAUSE, *Urbana, Illinois.*—The possibilities and limitations of existing methods for measuring total cross sections for low energy neutrons (usually photo-neutrons of a few hundred-kev energy) are discussed. It is shown that a new procedure for such measurements is desirable. A method based on the particular phenomena arising in the slowing down of low energy neutrons[1] has been developed and applied in a few cases. Photo-neutrons from RdTh+D_2O (220 kev) were used in this work. The possibilities and limitations of the new method will be discussed.

[1] M. Goldhaber and R. D. O'Neal, Phys. Rev. **60**, 834 (1941).

7. Absorption of High Energy Quanta. G. D. ADAMS AND R. K. CLARK, *University of Illinois.*—Absorption measurements have been made for quanta of the high energy tip of the Bremsstrahlung spectrum from the 20-Mev betatron.[1] The tip is isolated by using Cu monitor and detector sheets, assuming the maximum energy of the spectrum is above the threshold ($\sim$10.5 Mev) for the Cu^{63} (γ, n) Cu^{62} reaction. The positron activity of Cu^{62} is observed with Lauritzen electroscopes.

Be, C, Al, Fe, and Pb have been used as absorbers. The resulting absorption checks within 1 percent the theoretical values calculated from standard formulae[2] for an equivalent quantum energy.

Running the betatron at 13 Mev max., the equivalent quantum energy is about 11.75 Mev, for which the absorption coefficients follow:

Z	$_4$Be	$_6$C	$_{13}$Al	$_{26}$Fe	$_{82}$Pb
τ (cm^{-1})	0.0278	0.0292	0.0601	0.234	0.635

Experiments with other monitor and detector sheets are now in progress.

[1] D. W. Kerst, Rev. Sci. Inst. **13**, 387 (1942).
[2] W. Heitler, *Quantum Theory of Radiation* (Oxford, 1936).

8. The Nature of the Primary Cosmic Radiation. MARCEL SCHEIN AND MARIO IONA, JR., *University of Chicago.*—Using a cosmic-ray balloon apparatus, the number of cosmic-ray showers below a lead thickness of 2 cm was measured in coincidence with the vertical rays passing through 4 cm of lead. To register a maximum number of showers, two Geiger-Mueller counters were placed directly below the 2-cm lead block. This arrangement made it possible to measure all the showers of 2 or more particles with an angular divergence of more than 20 degrees. Since a primary electron, entering the earth's atmosphere at Chicago (latitude 52° N), carries a minimum energy of 3×10^9 ev, it is expected that in the first radiation unit each of these electrons passing through a lead thickness of 4 cm generates below 2 cm of lead a shower of more than 15 particles. At altitudes corresponding to an average pressure of 2.5 cm Hg, it was found that from all the particles passing through the 4 cm only 9.8 percent emerge below 2 cm of Pb with a shower of 2 or more particles. This is in accordance with the results of previous experiments* and demonstrates that the main body of the primary cosmic radiation does not consist of electrons.

* Marcel Schein, William P. Jesse, and E. O. Wollan, Phys. Rev. **59**, 615 (1941); W. F. G. Swann, Phys. Rev. **59**, 770 (1941); **59**, 836 (1941).

9. Slow Mesotrons in the Stratosphere. MARIO IONA, JR. AND MARCEL SCHEIN, *University of Chicago.*—With a set of Geiger-Mueller counters in fourfold coincidence, the vertical intensity of cosmic rays through 4 cm of Pb was measured in the high atmosphere. A second fourfold coincidence set was used for measuring the intensity of the penetrating component through 8 cm of Pb. Plotting the difference between the two intensities as a function of altitude, we obtained a curve with a maximum at an altitude of 20 kms (atmospheric pressure 4.5 cm Hg). The majority of the cosmic rays with a penetrating power between 4 and 8 cm of Pb must consist either of mesotrons or of protons. This follows from the fact that only very few of these particles generate showers below a lead thickness of 2 cm (previous abstract). Mesotrons, having their momentum in the above given range, have a specific ionization in air which is nearly equal to the average specific ionization of cosmic rays on the surface of the ground. On the other hand protons with these momenta show a much heavier ionization than that mentioned above. Since the average specific ionization of cosmic rays in the stratosphere is nearly equal to that on the ground, it can be concluded that the majority of the particles which penetrate 4 cm but are stopped by 8 cm of Pb consist of low energy mesotrons (average kinetic energy 1.2×10^8 ev).

10. Experimental Determination of the Disintegration Curve of Mesotrons. BRUNO ROSSI AND NORRIS NERESON, *Cornell University.*—The disintegration curve of mesotrons at rest has been experimentally determined by investigating the delayed emission of electrons which takes place after the absorption of mesotrons by matter. For the purpose of this measurement, a circuit has been developed which records the time intervals between the discharges of two sets of Geiger-Müller counters. As a preliminary experiment the natural time lags of the counters to be used in the main experiment were investigated. Most of the time lags were found to be smaller than 0.2 microsecond with very few larger than 0.5 microsecond. In the main experiment two sets of counters were used to detect the arrival of the mesotron on a brass plate and the emission from the plate of the corresponding decay electron, respectively. About 500 disintegration processes were recorded in which the delays between the discharges of the two sets of counters were greater than 0.55 microsecond. Within the experimental errors the distribution of the observed delays follows an exponential law corresponding to a mean lifetime of 2.3 ± 0.2 microseconds.

FRIDAY AFTERNOON AT 4:30

Room 117, Pathology Building

Applications of Nuclear Physics to the Biological Sciences.

J. G. HAMILTON, *University of California at Berkeley*, or
I. PERLMAN, *University of Chicago.*

Session B

SATURDAY MORNING AT 9:30 A.M.

Room 122, Social Science Building

Invited Paper

Problems in the Theory of Atmospheric Cosmic-Ray Showers.
P. AUGER, *University of Chicago.*

Contributed Papers

11. Acceleration of Decay in the Anode Effect by Partial Excitation. PAUL L. COPELAND, *Illinois Institute of Technology.*—After the apparent contact potential of an unheated electrode in a vacuum tube relative to the cathode has been shifted by passing an abnormally large current to it for a short time (a process called excitation), there is a drift toward the normal condition (decay). The contact potential shift is nearly linear when plotted against the logarithm of the time measured from the change in the exciting current.[1] In the present work a large shift in the contact potential of the grid in a triode was produced by excitation for one minute. Then the decay was followed for several minutes. After this an excitation current was allowed to flow for 0.004 sec. This pulse resulted in: (1) a temporary increase in the contact potential relative to the normal state, and (2) an increased rate of drift. The net result was a more rapid approach to normal. If the decay curve is broken into sections divided by the exciting pulses and in each section the contact potential is plotted as a function of the logarithm of the time after the beginning of the section, it is found that each section is nearly linear.

[1] P. L. Copeland, Phys. Rev. **57**, 625 (1940); P. L. Copeland and G. G. Carne, Phys. Rev. **61**, 635 (1942).

12. The Temperature Coefficient of Secondary Emission and the Work Function of Molybdenum Targets Coated with Beryllium and Treated with HCl. WILLIAM R. KENNEDY AND PAUL L. COPELAND, *Illinois Institute of Technology.*—Molybdenum strips about three mm wide were outgassed in a vacuum, and thick films of beryllium were evaporated on them. These strips were washed in air with HCl and then used as targets in an experimental secondary emission tube. Temperature control of the target was provided by means of an external battery connected across the target. Secondary electron emission measurements as a function of primary electron energy were made for temperatures from room temperature up to temperatures at which thermionic emission became appreciable. It was found that the secondary electron emission remained substantially constant over this range of temperatures. A maximum of about 2.5 secondaries per primary appeared at primary electron energies of around 500 electron volts. Thermionic emission data were taken, and the Richardson plot gives a work function of about 5.5 volts.

13. Diffusion Rate of Carbon in Iron Alloys. R. SMOLUCHOWSKI.—Studies of rates of various transformations and reactions in iron alloys seem to indicate that certain elements have a definite influence on the rate of diffusion of carbon in gamma iron. In particular, cobalt shows a pronounced accelerating influence. By direct measurement of the rate of carbon diffusion in iron-cobalt alloys, this conclusion is confirmed and an increase of the diffusion coefficient established. An addition of 4 percent cobalt decreases the activation energy by about 2500 calories down to 30,000 calories, corresponding to an almost twofold increase of the diffusion rate at one atomic percent carbon concentration. At higher carbon content the accelerating influence of cobalt is smaller. This property of cobalt is unusual especially in view of the fact that both manganese and nickel are known to have practically no influence on the diffusion of carbon. Similar experiments with tungsten-iron and molybdenum-iron alloys indicate that these two elements decrease the diffusion rate of carbon. The change of diffusion rates, while well measurable, are too small to explain changes in other reactions.

14. Equilibrium Between the Alpha- and Gamma-Phases of Pure Iron. R. S. WEHNER AND WHEELER P. DAVEY, *Pennsylvania State College.*—During experiments

made by A. Wangsgard to determine the A_3c point in pure iron, it was noticed that both alpha- and gamma-iron could be found together between the A_3c and the A_3r points. This was contrary to the current ideas of metallurgists. A careful examination was therefore made of the structure of pure iron (from iron carbonyl, kindly supplied by Professor R. Mehl), between the A_3c and the A_3r points, using an x-ray spectrometer so built that the specimen was kept in a hydrogen atmosphere in a furnace whose temperature could be automatically kept constant to within 0.25° at any desired temperature in the neighborhood of 910°C. It was found that when pure iron was cooled below the A_3c point, it contained both alpha- and gamma-phases over a temperature range of several degrees. Both phases were kept under observation over a period of two hours with readings of temperature, angle of x-ray diffraction, and intensity of diffracted beam, all measured at one minute intervals. It is evident that alpha- and gamma-iron can exist in equilibrium with each other at all temperatures between the A_3c and A_3r points. This is consistent with the phase rule.

15. Temperature Rise in Rubber on Fast Stretching. R. L. ANTHONY AND S. L. DART, *University of Notre Dame.*—The rise in temperature on fast stretching of rubber was first investigated quantitatively by Joule. The thermodynamic relationship of this effect to other thermoelastic phenomena was established by Kelvin. Later investigations have yielded widely varied results. In particular, previous results obtained for the temperature rise accompanying adiabatic stretching are much too small, as may be checked by simple sensory observations. Employing a galvanometer of period 1/10 sec., and sensitivity 10^{-7} amp./mm, the authors have obtained values of this temperature rise of the expected order of magnitude. For example, an accelerated latex vulcanizate gave a temperature rise of 14.7°C at 600 percent extension. The change in temperature was studied as a function of both extension and retraction. These investigations show that at least a part of the disagreement between earlier workers was due to differences in the samples studied and also to heat losses resulting from long galvanometer recording times. The variety of samples studied, as well as the range of extensions employed, make this investigation more comprehensive than previous work.

16. Equation of State of Synthetic Rubbers. L. E. PETERSON AND EUGENE GUTH, *University of Notre Dame.*—The equations of state of several representative synthetic rubbers have been obtained experimentally for the first time. Comparing the results so obtained with the general statistical theory of rubber elasticity developed by James and Guth the applicability of the theory to synthetic rubber was checked and its usefulness thereby extended. The equation of state, i.e., the relationship between the stress as a function of strain and temperature, was obtained by employing a relaxation method. The synthetics investigated exhibited plastic flow and permanent set to a greater degree than natural rubber. Nevertheless, they displayed the same general features of stress-temperature behavior and also a thermoelastic inversion point in general accordance with the theory. By the application of thermodynamics, the experimental equation of state was resolved into two additive components—the internal energy and entropy contributions. The entropy component agreed with the theoretical curve and accounted for the major portion of the stress in each case.

17. Theory of X-Ray Diffraction in Mosaic Crystals. W. H. ZACHARIASEN, *University of Chicago.*—A great many crystals are neither so perfect that the x-ray diffraction data can be interpreted by means of the dynamical theory, nor so imperfect that the Darwin theory of the ideal mosaic crystal is valid. A general theory of x-ray diffraction applicable to mosaic crystals of this intermediate type has been developed by the writer. Solutions have been obtained only for mosaic crystals which are in the form of plane parallel plates since the boundary conditions are difficult to handle for other geometrical shapes. The expression for the diffraction pattern $\mathfrak{P}$ is given in terms of the thickness t of the constituent blocks, the distribution function W for the orientations of these blocks, and the diffraction pattern P of a single block. The integrated reflecting power $\mathfrak{R}$ cannot be expressed in simple form unless the half-width of the distribution function W is large compared to the half width of the diffraction pattern P. If this condition is fulfilled one finds for the symmetrical Bragg case and thick crystal plate

$$\mathfrak{R}=[R/1-\exp(-2\mu t/\gamma)],$$

where R is the integrated reflecting power of a single block (as known from the dynamical theory), μ the linear absorption coefficient, and γ the direction cosine of the incident beam. This result is identical with that of Darwin for very small block size, but as t increases $\mathfrak{R}$ approaches the perfect crystal value.

18. Morphic Double Refraction in Presence of Strong Intrinsic Anisotropy. WILFRIED HELLER, *University of Minnesota.*—Morphic double refraction in dispersed systems of oriented intrinsically isotropic anisometric ultramicroscopic particles disappears if the refractive indices of medium and particles (n_m; n_p) become equal. The same holds (Ambronn) for particles with weak intrinsic double refraction (mean index $n_p \sim n_\alpha \sim n_\gamma$). The case of strong intrinsic anisotropy has now been considered using tartrazine (n_α: 1.49; n_γ: >1.8) and magnetic orientation. Morphic double refraction decreased with increasing n_m without any indication of reversal when $n_m = n_\alpha$, or $= n_p$ (1.59), or $= 1.66$ (the highest n_m investigated. All data for 5790A). Morphic double refraction appeared therefore to reach a zero value only if $n_m = n_\gamma \cdot n_\gamma$ was the refractive index perpendicular to the rod axis of the acicular crystals. The crystal rods were oriented perpendicular to the direction of the field. The direction of n_γ coincided therefore with the direction of the symmetry axis of revolution of the anisotropic dispersed system. This result suggests the rule: morphic double refraction disappears if the periodicity of the refractive index is

suppressed parallel to the symmetry axis of revolution (extraordinary direction) of a morphically anisotropic dispersed system. Ambronn's above rule appears as an implicite approximation.

19. The Localization Phenomenon in G-M Counters. M. H. WILKENING AND W. R. KANNE, *Illinois Institute of Technology.*—Localization of the discharge in fast counters has been further investigated. Splitting the cathode will localize the discharge, if the separation is sufficiently great, simply by reducing the field intensity in that portion of the counters to threshold values or below. A similar stopping of the discharge spread along the wire has been effected by placing insulating materials of varying geometry and position in the counter. A bead on the wire or a ring fitted into the cylinder are both effective arrangements. The insulating materials reduce the field intensity by the accumulation of surface charges. The localization phenomenon was not observed when slow counter fillings such as pure argon or hydrogen were used. In these experiments the efficiency of localization was found to depend on (1) geometry and nature of the localizing device, (2) overvoltage at which the tube was operated, and (3) concentration and kind of gas filling used. The results of these investigations are consistent with the theory that photons are the chief agents in producing new ions for the spread of the discharge along the wire. A strong absorption of these photons by the gas or vapor in fast counters is implied. The effect of various gases in this respect and the relation to fast counter action has been studied.

20. Construction of Surfaces of Constant Normal Separation. H. M. PARKER, *Tumor Institute of Swedish Hospital, Seattle.*—A surface generated from a given surface by the motion of the end of a normal of constant length traversing the surface is required in the construction of radium applicators. A modified copying machine using a universal link whose length is the required normal separation will cut such surfaces in wood, dental compositions, and plastics. Accuracy in the separation and easy correlation of corresponding points in the two surfaces are the advantages over previous hand methods.

Session C

SATURDAY AT 2:00 P.M.

Room 122, Social Science Building

Invited Paper

The Theory of Random Processes. G. E. UHLENBECK, *University of Michigan.*

Contributed Papers

21. $\Delta_1 F$ Values from Some Chlorine Dioxide Bands. JESSE B. COON, *Indiana University.*—Q branches have been previously reported in the sub-bands of four different bands of the violet absorption spectrum of ClO_2. Some P and R branches have now been identified in three of the bands. The $\Delta_1 F''$ values are the same for each band as would be expected since these bands have a common lower vibration state. It is found that within a given band all the $\Delta_1 F$'s are the same for one sub-band as for another. The values of B' and B'' calculated from the $\Delta_1 F$'s on the basis of the numbering of the lines are found to be constant throughout a given sub-band. The value of $B'-B''$ from the $\Delta_1 F$'s agree with the same constants found from second differences in the Q branches except for a small difference which remains constant for all bands. On the basis of $B''=0.306$ cm^{-1} from $\Delta_1 F''$'s, $B'-B''$, and $C'-C''$ previously reported, and the Cl−O distance for the lower state of 1.53A from electron diffraction, the angles for the lower and upper states are found to be 107° and 85°, respectively. But asymmetric top calculations show these small angles to be inconsistent with the observed spectrum. If the electron diffraction result is discarded and the value of 122° for the angle of the lower state is taken from vibration analysis, the Cl−O distance for the lower state turns out to be 1.44A and the angle of the upper state about 116° in fair agreement with vibration analysis.

22. A Vibrational Analysis of the Near Ultraviolet System of CS_2. LEONARD N. LIEBERMANN, *University of Kansas.*—Nine progressions in the long wave-length part (3400–3800A) of the λ3100 system of CS_2 have been found with vibrational interval 270 cm^{-1}. The interval 270 cm^{-1} has been previously identified with the deformation frequency, ν_2', in the excited state.[1] The identification of combination bands of the type $V_1'+V_2'$ shows that the symmetrical valence frequency, ν_1' is about 620 cm^{-1}. The intensity distribution of these bands is that which is to be expected from the Franck-Condon principle if the molecule becomes bent in the excited state. Several progressions of the type $V_1'V_2'O\leftarrow 030$, are pseudo $\Pi\rightarrow\Pi$ transitions, having angular momentum about the symmetry axis with $K=1$. This energy of rotation is found to produce a shift of 25 cm^{-1} in the excited states of these bands. Using this value in a formula relating the rotational energy and the apex angle, it is found that the molecule is bent to 160° in the excited state. The absence of strong bands in this

region involving the anti-symmetrical frequency is in agreement with the vibrational analysis. Substitution of the values $\nu_1' = 620$ cm^{-1}, $\nu_2' = 270$ cm^{-1}, and $2^\alpha = 160°$ in a formula based on a valence force model indicates that $\nu_3' = 1380$ cm^{-1}.

[1] L. N. Liebermann, Phys. Rev. **60**, 496 (1941).

23. Hyperfine Structure in the Band Spectrum of HgH. S. MROZOWSKI, *University of Chicago.*—The structure of the lines in the mercury hydride spectrum was investigated in the regions λ4300–3800 and λ3200–2600 by means of a Fabry-Perot etalon and a large Hilger prism spectrograph. Former investigations have shown that the complex structure of these lines is caused by the existence of several isotopes of mercury and can be very well explained by the presence of a normal isotope effect and a nuclear isotope shift. The existence of a hyperfine structure splitting for the isotopic molecules $Hg^{199}H$ and $Hg^{201}H$ was considered at that time very plausible but could not be proved.* The present experiments carried out with a higher resolving power (roughly one million) gave for the first time a clear proof of the presence of a hyperfine structure in a band spectrum. Differences in the structure (number of components) and in the intensity distribution between lines belonging to the Q branches on the one hand, and lines belonging to the P and R branches on the other hand were detected and studied quantitatively. The results can be explained only by the assumption of a splitting of lines belonging to each of the odd isotopes of mercury into at least two hyperfine structure components; the value of the splitting being different for the two types of lines (*a*) Q, (*b*) P and R.

* Cf. S. Mrozowski, Phys. Rev. **58**, 332 (1940) and the references to the older work there.

24. Quantum Yield of Diacetyl Fluorescence. G. M. ALMY AND P. R. GILLETTE, *University of Illinois.*—The quantum yield of fluorescence of diacetyl, excited by radiation of λ4047 and λ4358, has been measured and found to be 0.145 ± 0.03. It is approximately independent of pressure. On the other hand, the yield with excitation of λ3650, as first observed by Henriques and Noyes,[1] increases apparently from zero at zero pressure to nearly the value obtained for the longer wave-length excitations at a pressure of 5 cm Hg. This marked difference in pressure effect for different energies of excitation is explained by assuming that predissociation occurs at a level between those reached upon λ3650 and λ4047 excitations. By removing vibrational energy collisions can save for fluorescence a molecule excited by λ3650, but do not play this role in the case of molecules with excitation energy below the predissociation limit. The observed properties of diacetyl fluorescence can be explained in terms of a model involving a metastable state just below the state reached on absorption. Such a state, electronically metastable, has been predicted by McMurry[2] who estimates, however, that the probabilities of transition from both states are largely due to electronic-vibrational coupling.

[1] Henriques and Noyes, J. Am. Chem. Soc. **62**, 1038 (1940).
[2] McMurry, J. Chem. Phys. **9**, 241 (1941).

25. Raman Spectra of Some Diacetylenes. ARNOLD G. MEISTER, FORREST F. CLEVELAND, AND M. J. MURRAY, *Illinois Institute of Technology.*—Raman frequencies, intensities and depolarization factors have been obtained for 2,4-hexadiyne, 3,5-octadiyne, 4,6-decadiyne, 5,7-dodecadiyne, and 6,8-tetradecadiyne. Relative intensities and depolarization factors were obtained by use of a Gaertner microdensitometer. Comparison of the results for 2,4-hexadiyne ($CH_3-C\equiv C-C\equiv C-CH_3$) with Crawford's analysis of the Raman and infra-red spectra of 2-butyne ($CH_3-C\equiv C-CH_3$) indicates that the lines observed at 1020, 1381, 2847, 2915, and 2955 cm^{-1} originate from vibrations of the CH_3 group. Lines observed near 460, 485, and 2260 cm^{-1} for 2,4-hexadiyne appear also in the spectra of the other four compounds and probably originate from vibrations of the $R-C\equiv C-C\equiv C-R$ group. There was also some indication of a very weak line near 993 in all of the compounds and lines were observed near 1255 and 956 for all except 5,7-dodecadiyne and 4,6-decadiyne, respectively. Frequencies near 530, 1225, 1295, 1328, and 1427 cm^{-1} were observed for all except 2,4-hexadiyne. In the triple bond region, three lines were observed at 2224(26), 2263(1000), and 2308(3) for 2,4-hexadiyne, but only a single strong line near 2256 for the other four compounds. The line near 2860, observed for the last three compounds, increases in intensity with increasing number of CH_2 groups. A line was observed near 2960 for all the compounds except 3,5-octadiyne for which it was observed at 2982 cm^{-1}.

26. Raman Spectra of Some Ethane-Like Molecules. DWIGHT T. HAMILTON, FORREST F. CLEVELAND, AND M. J. MURRAY, *Illinois Institute of Technology.*—In continuing a study of ethane-like molecules, the Raman spectra of several solutions of C_2Cl_6 and C_2Br_6 have been obtained. Displacements in cm^{-1}, relative intensities and depolarization factors for C_2Cl_6 are: 162(v.w.)P, 223(450)0.80, 340(372)0.86, 431(1000)0.15, 859(219)0.81, 975(33)0.35; for C_2Br_6: 139(530)0.47, 204(780)0.83, 255(1000)0.13, 768(462)0.70. Relative intensities and depolarization factors were obtained by use of a Gaertner microdensitometer. The fundamental frequencies of C_2Cl_6 were calculated using Stitt's[1] modified valence force type potential function for ethane, with the force constants $K_C = 4.00$, $K_{Cl} = 2.00$, $K_\alpha = 0.75$, $K_\beta = 0.35$, $K_{\alpha\beta} = -0.65$, $K_{C\gamma} = -1.36$ in units of 10^5 dynes/cm. With this set of force constants Stitt's equations give the $\Delta\nu$ values 869, 341, 209 for E_g; 973, 310, 282 for A_{1g}; 869, 321, 100 for E_u; 1001, 310 for A_{2u}. Were additional data at hand, Stitt's nine-constant potential function could probably be used to give better agreement between calculated and observed A_{1g} frequencies, and perhaps better establish the above calculated frequencies which overlap at ~315 and 869. Also, if further investigation should reveal that certain of the observed frequencies are overlapping or perturbed fundamentals, an adjustment of the above force constants would be necessary, which might also lead to better agreement between calculated and observed frequencies.

[1] Fred Stitt, J. Chem. Phys. **7**, 297 (1939).

27. Raman Spectra of Some Octenes and Octynes. FORREST F. CLEVELAND, *Illinois Institute of Technology.*—Raman frequencies, relative intensities and depolarization factors have been obtained for 1-octene, *cis*+*trans* 2-octene, 3-octene, 4-octene, 4-octyne, and 1-octyne. Some of the spectrograms were made with a Hilger E-518 spectrograph. Sharp lines could be measured to the nearest cm^{-1} while the over-all accuracy was approximately 3 cm^{-1}. The speed of the Hilger spectrograph was such that, with a slit width of 0.08 mm and with Agfa Superplenachrome Press film, a spectrogram of CCl_4 upon which it was possible to measure frequencies for 5 Stokes and 3 anti-Stokes lines could be obtained in 1 min. In the earlier work, trouble was experienced with motion of the film during the long exposures, with consequent broadening or doubling of the lines. A change to Eastman 103-J spectroscopic plates eliminated this difficulty. The relative intensities and depolarization factors were obtained by use of a Gaertner microdensitometer. The density of the line D_L and the density of the background D_B were obtained and the corresponding intensities I_L and I_B were read from a previously prepared density-intensity table. The true intensity of the line was taken as (I_L-I_B). Comparison of the relative intensities for 4-octyne with the estimated intensities previously obtained in this laboratory indicated that the so-called "estimated intensities" are really estimates of the densities rather than of the intensities of the lines.

28. The Measurement of Photographic Densities by the Scatter of X-Rays. J. C. M. BRENTANO, *Northwestern University.*—The photographic measurement of the total radiation received on an area with uneven density distribution by ordinary absorption densitometry requires a point to point evaluation based on a blackening curve. When use is made of a linear relation the measurement is simplified. This is done in a scatter method in which the photographic effect is measured by the scattering of light from the silver grains. The amount scattered is proportionate to their number and when the reciprocity law is satisfied (with x-rays), the grain number—within a certain density range—is with good approximation proportionate to the radiation received. An area of uneven density as represented by a spot of an x-ray diffraction pattern can then be evaluated as a whole. By making use of the scattering of x-rays in preference to that of visible light, certain limitations can be avoided and higher densities can be evaluated.

29. Production, Concentration, and Decomposition of Ozone by Ultraviolet Light. ARTHUR W. EWELL, *Worcester Polytechnic Institute.**—With the increasing use of bactericidal ultraviolet lamps it has become very desirable to have more information about the accompanying production of ozone—the only feasible agent for protecting surfaces not exposed to direct or scattered radiation. A low pressure mercury arc lamp of the type of the 30-inch Westinghouse Sterilamp gives an amount of ozone of the order of 1/100th gram per hour. A gentle air motion increases the yield. All the ozone is produced within a few feet of the lamp. The rate of decomposition of the ozone after the lamps are turned off is faster the greater the surfaces compared with the volume, the higher the temperature, the higher the humidity, and the more 2537 radiation present. The most important factor, the equilibrium ozone concentration, in an enclosure of several cubic meters is proportional to the ozone produced, inversely proportional to the volume, reduced to about one-third when the relative humidity changes from a few percent to near saturation and to about one-half when the temperature is raised from 7° to 32°C. In the case of the Westinghouse Sterilamp, it is approximately 30 percent less if the accompanying 2537 radiation is doubled.

* Consultant, Westinghouse Electric & Manufacturing Company.

SUPPLEMENTARY PROGRAMME

30. An Indirect Detection of Absorption Bands in Strongly Light Scattering Dispersed Systems. WILFRIED HELLER AND ETIENNE VASSY, *University of Minnesota.*—Strong light absorption due to scattering may "wash out" or completely hide bands of consumptive ("true") absorption. Such bands may then be detected and defined by an indirect method. The relation $-\log k=c+n\log\lambda$ (k: absorption coefficient; c: a constant) governs the absorption curve if nothing but the wave-length is varied. In absence of consumptive absorption, $n=4$ in the region of Rayleigh scattering. As higher electric partial waves enter, n decreases. In no instance can n assume values >4. However, in presence of consumptive absorption, n may become >4 and it will vary strongly with λ. The differential analysis of the slope of curves drawn according to the above relation may therefore often permit to detect and to delimitate hidden or barely visible bands of consumptive absorption. The method has been applied for detecting in iron oxide sols the existence of strong consumptive absorption below 5500A. The absorption spectra gave no direct indication of it since they were completely dominated by conservative absorption.

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